# Towards standardisation of the Sensory Profile Checklist Revisited: Perceptual and Sensory Sensitivities in Autism Spectrum Conditions

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## Abstract

Although sensory and perceptual symptoms have been associated with ASC from the time that autism was first defined as a diagnosis (Kanner, 1943), and despite many personal accounts from individuals with ASC themselves (Grandin, 2009; Lawson, 1998; O'Neill, 1999; Williams, 1992), there is a long lasting debate whether sensory symptoms are a component of core ASC deficits or a co-morbid phenomenon. The current research aimed to explore the pattern of sensory and perceptual experiences in ASC using the Sensory Profile Checklist Revisted (SPCR; Bogdashina, 2003). The measure has been useful for guiding clinical intervention, but the structure, reliability and validity is yet to be analysed. The SPCR was completed by support workers based on their observations of 38 individuals with clinical diagnosis of ASC. 40 individuals from the general population also completed the measure based on their observations of someone they knew for more than 6 months. Reporting participants also completed the Autism Quotient (AQ; Baron-Cohen, 2001) and the Adult/ Adolescent Sensory Profile (ASP; Brown & Dunn, 2002). A principle components factor analysis using promax rotation was conducted for the SPCR, with 4 factors explaining 30.82% of the variance. Internal consistency was high with alphas ranging from .90 to .95. Principle axis factoring was used to analyse the factor structure of ASC traits underlying the AQ. The 3 factor solution, which explained 48.31 % of the variance, was chosen. Internal consistency was moderate to high, with alphas ranging from .56 to .92. Individuals with an ASC were found to score significantly higher on the SPCR than healthy controls ($b$=78.496, $t(77)$=4.577, $p$=.05). AQ scores were found to have a significant effect on SPCR scores with a single score increase in AQ scores predictive of 3.49 point increase in SPCR scores ($b$=3.49, $t(76)$=4.795, $p$<.05). ASP scores were found to have a significant effect on SPCR scores, with a single score increase in ASP scores predictive of 2.78 point increase in SPCR scores ($b$=2.78, $t(36)$=8.885, $p$<0.05). The results suggest that sensory and perceptual processing styles of individuals with ASC are significantly different to those of healthy controls. The extracted constructs differ from those originally suggested by Bogdashina (2003), however, it could be argued that wih tighter controls and a larger sample size, the extracted factors would be separated further. The high correlation between items of the SPCR and the AQ suggest that the SPCR is useful tool for evaluating the sensory and perceptual experiences of individuals with ASC. Whilst it cannot be claimed to aid diagnosis, the structure of the measure is such that it would be a useful tool for parents, carers and clinical professionals to use as a guide for intervention targeted at relieving the need to engage in sensory seeking or sensory avoiding behaviours.

## Introduction

Autism is currently considered part of a continuum of disorders which includes Asperger syndrome and pervasive developmental disorder-not otherwise specified (PDD-NOS), collectively referred to as pervasive developmental disorders (PDD) within the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) of the American Psychiatric Association (APA, 2000). Like many other neurological and psychiatric conditions, autism is both clinically and genetically heterogeneous (Bill & Geschwind, 2009) and due to difficulty in accurate sub-typing, it has been grouped with PDD-NOS and Asperger syndrome to be referred to as Autism Spectrum Condition (ASC) for clinical and research purposes (Tan, Doke, Ashburner, Wood, & Frackowiak, 2010). Commonly referred to as the triad of impairments (Wing & Gould, 1979), the criteria for a clinical diagnosis of ASC include qualitative impairments in social interaction and communication, and restricted or stereotyped behaviours, activities and interests, manifest before the age of three. Examples of social and communication impairments include poorly modulated eye contact, lack of social or emotional reciprocity, lack of spontaneous shared enjoyment with others, and delayed, absent or idiosyncratic language development. Examples of restricted or stereotyped behaviours, activities or interests include rigid adherence to non-functional routines or rituals, repetitive motor mannerisms, and a preoccupation with parts of objects. A diagnosis for Asperger syndrome requires that the above criteria be met but with no clinically significant general delay in language or cognitive development, age-appropriate self help skills, adaptive behaviour or curiosity about the environment (APA, 2000). Whilst these behavioural characteristics are useful for diagnosis, they cannot be considered as primary features and fail to determine what the fundamental impairment or impairments might be.

Based on current criteria the diagnosis of an ASC can be made relatively reliably as early as two years of age (Zwaigenbaum, Bryson, Lord, Rogers, Carter & Carver, *et al.*, 2009), and current prevalence estimates of approximately one in every one hundred individuals, make ASCs among the most prevalent childhood developmental disorders (Rice, Baio, Van Naarden, Doemberg, Meaney & Kirby, 2007). They have also shown that between 25% and 40% of cases have learning disabilities with IQs of under 70 (Baird et al, 2000; Chakrabarti & Fonbonne, 2001). Although current improvements in diagnostic criteria and refined methodologies may be contributers, the prevalence appears to have increased in recent surveys (Bertoglio & Hendren, 2009; Fombonne, 2009; Lenoir, Bodier, Desombre, malvy, Abert, Ould Taleb *et al.,* 2009), leading to increased attention to the diagnostic and principal features of ASC. However, despite half a century of research since Kanner's original reports of autism in 1943, ASC remains a lifelong and complex neurodevelopmental condition with unknown aetiology (Kanner, 1943; Johnson & Myers, 2007). There is significant heterogeneity in clinical phenotype, and no identified symptoms or physiological correlates are unique or universal to ASC (lord & Spence, 2006). As such, there is general consensus that the causes of ASC are multi-factorial, with the most common theories based on a combination of genetic and environmental influences.

Although sensory and perceptual symptoms have been associated with ASC from the time that autism was first defined as a diagnosis (Kanner, 1943), and despite many personal accounts from individuals with ASC themselves (Grandin, 2009; Lawson, 1998; O'Neill, 1999; Williams, 1992), there is a long lasting debate whether sensory symptoms are a component of core ASC deficits or a co-morbid phenomenon. With the development of standardised, norm referenced questionnaires over the past decade an increased interest in sensory symptoms of ASC has been witnessed, and with evidence for severity, universality and uniqueness of sensory and perceptual symptoms in ASC growing (Ben-Sasson, 2009), their role in diagnosis and intervention may become more central. Individuals with ASC are commonly reported to exhibit behaviours associated with sensory sensitivity such as covering their ears, or becoming distressed in the event of unexpected sounds, leading to an increased interest in the importance of sensory processing abilities over recent years. During the 1960s and 1970s the idea of sensory perceptual abnormalities as one of the core features of the disorder was put forward (Rimland, 1964), and the theory of sensory dysfunction formulated (Delacato, 1974), yet until recently the lack of systematic investigation has meant that these abnormalities or different experiences have remained associated, but not essential, features of ASC diagnosis. Sensory processing involves the ability to capture, systematize and make sense of various sensations. The sensory systems are the foundation for the acquisition of environmental information in order to support adaptive and successful responses to environmental demands. The type and intensity of response to sensory stimulation differs from one individual to another, with some presenting with clinically significant difficulties regulating their responses in an adaptive manner (Ben-Sasson et al., 2009).

The nervous system operates based on excitatory and inhibitory neuronal activity. Excitatory neurons increase the activity related to a particular event or stimulus whereas inhibitory neurons decrease or block the neuronal activity related to an event or stimulus. It is this sensory modulation which determines how and when the nervous system responses are generated. When sensory modulation is working efficiently, the nervous system responds to some stimuli whilst ignoring others, an action achieved through a process of habituation and sensitisation. At the cellular level, initial presentation of a stimulus will increase the amplitude of neuronal response, yet electrophysiological recordings reveal that the amplitude of the receptor potentials elicited by the stimulus decreases progressively during the course of repetitive stimulation (Wood, 1971; 1988). Without habituation, people would be constantly distracted by each and every new stimulus in the environment, and unable to concentrate their attention on those things most relevant and important at the time. Sensitisation on the other hand enhances potentially important stimuli. Some stimuli require attention right away, for example in the anticipation of harm or danger associated with a particular stimulus, recruiting greater volumes of activated neurons. As individuals develop, their nervous systems evolve and their experiences shape the nervous system's evolution, carefully balancing habituation and sensitisation to support adaptive behaviour and appropriate responses to environmental demands. People with atypical sensory processing may display exceedingly high thresholds (*i.e.* habituation, hyposensitivity), or exceedingly low thresholds (*i.e.* sensitisation, hypersensitivity). When thresholds are too high, people react less readily to stimuli, whilst when they are too low, people react too quickly and frequently to stimuli. Such central nervous system thresholds are established by genetic endowment and personal life experiences (Clark & Clark, 1976; Kandel, Schwartz, & Jessell, 2000). The delicate balance between appropriate sensory activation and accurate perceptual development suggests potential for pathology.

Rates of sensory processing dysfunction are estimated to be between 5% and 16% in the general population (Ahn et al., 2004; Ben-Sasson et al., 2009), but despite not being considered as a core deficit for diagnostic criteria, may be as high as 90% in individuals with ASC (Baranek et al., 2006; Baranek et al., 2007; Leekham et al., 2007; Tomcheck & Dunn, 2007; Baker et l., 2008), suggesting universality across the spectrum (Ben-Sasson et al., 2009). Atypical behavioural and physiologic responses to sensory stimuli are reported in various groups with clinical diagnoses (Ermer & Dunn, 1998; Miller et al., 1999; Rogers et al., 2003; Leekham et al., 2007), and are associated with significant problems in adaptive behaviour and participation in daily life activities (Cohn et al., 2000); Rogers et al., 2003; Kern et al., 2006; Hilton et al., 2007; Bar-Shalita et al., 2008). However, a wide range of sensory disturbances are reported in children with ASC (Baranek, 1999; Iarocci & McDonald, 2006; Liss et al., 2006: Ben-Sasson et al., 2007; Kern et al., 2007; Baker et al., 2008; Minshew & Hobson, 2008), and evidence suggests that the profile of atypical sensory-related behaviour is different than children with other developmental disorders (Ermer & Dunn, 1998; Rogers et al., 2003; Baranek et al., 2006). It is well supported that children with ASC experience significant differences in their sensory processing compared with their neurotypical peers (Lane, Young, Baker & Angley, 2010; Baker, Lane, Angley, & Young, 2008; Ben-Sasson, Carter, & Briggs-Gowan, 2009;

McIntosh, Miller, Shyu, & Hagerman, 1999; Miller, Anzalone, Lane, Cermak, & Osten, 2007; Rogers & Ozonoff, 2005; Baranek, *et al.*, 2007; Baranek, David, Poe, Stone, & Watson, 2006), and various studies report sensory processing difficulties associated with ASC are multimodal and variable, including all primary sensory modalities (Adamson, O'Hare, & Graham, 2006; Kern et al., 2007; Kern, Garver, Carmody, Andrews, Mehta, & Trivedi, 2008, Leekam, *et al.*, 2007).

Three types of sensory modulation disorders have been identified: sensory over-responsiveness; sensory under-responsiveness; and sensory seeking behaviour. Over-responsiveness occurs when the person responds to sensory input more quickly or with increased intensity than typically observed. Sensory under-responsiveness occurs when the child actively engages in actions that provide intense sensory input, and sensory seeking behaviour occurs when the person actively engages in actions that provide intense sensory input. (Hilton, Harper, Kueker, Lang, Abbacchi, Todorov & LaVesser, 2010). The early onset of sensory modulation disorders in toddlers with ASC indicates that this deficit begins to impact child development at an early age (Ben-Sasson et al., 2007), and difficulties in sensory modulation are often the first signs that parents notice in their children with ASC (Baker et al , 2008). From a sensory integrative perspective, conceptual and behavioural learning occurs when a person receives accurate sensory information, processes it, and uses it to organise appropriate responses. When people receive inadequate or unreliable sensory information, their processing style may result in disrupted responses (Dunn, 1997), difficulty interacting and relating to people or objects, and is also related to social, cognitive and sensorimotor development (Bundy, Shia, Long, & miller, 2007; Ashburner, Ziviani, & Rodger, 2008; Dickie, Baranek, Schultz, Watson, & McComish, 2009). For example, Hilton and colleagues found a strong relationship between atypical sensory responsiveness and social impairment for typically developing children and for those with ASC. Atypical sensory responses to multisensory, tactile, oral and olfactory stimuli were identified as possible predictors of social severity. The importance of multisensory responsiveness may be explained by the multisensory nature of social interaction and social impairment may be a general developmental effect of proximal sensory abnormalities offering implications for diagnosis and intervention (Hilton *et al.*, 2010).

Atypical responses to auditory stimuli have been frequently reported (Tomcheck & Dunn, 2007), with hyper-responsiveness to typically non-noxious auditory stimuli, or under-responsivity to auditory stimuli common to several studies of children with autism (O'Neill & Jones; Rosenhall, Nordin, Sandstorm, Ahlsen & Gillberg, 1999 ; Baranek, 1999; Osterling & Dawson, 1994). Hyperresponsiveness to visual stimuli might be seen in children who prefer to be in the dark or avoid bright lights, while hypo-responsiveness might involve looking intensely or staring at objects or people (Dunn, 1999). Visual motion perception and pursuit eye movement deficits have been reported in individuals with ASC (Takarae, Luna, Minshew & Sweeney, 2008). Increased visual acuity (Ashwin, Ashwin, Rhydderch, Howells, & Baron-Cohen, 2009) and prolonged papillary light reflex latency, smaller constriction amplitude, and lower constriction velocity (Fan, Miles, Takahashi, & Yao, 2009) have also been observed in individuals with ASC in comparison to a control group, and may help to explain the atypical visual responsiveness sometimes seen. Hyper-responsiveness to vestibular stimuli might include becoming anxious or distressed when feet leave the ground, while hypo-responsiveness might include inability to sit still or rocking unconsciously (Dunn, 1999). The ability to navigate in a world and make appropriate motor responses is dependent upon the development of accurate internal representations of the body's orientation in space and what happens with movement (Green, Shaikh, & Angelaki, 2005). The otolith organs and the semicircular canals work together to construct this internal model, and are also dependent on the senses of joint proprioception and vision (Kuo, 2005). Difficulties in vestibular modulation, including difficulties with balance and body orientation are often reported in children with ASC (Kern, Garver, Grannemann, Trivedi, Carmondy, Andrews, & Mehta, 2007). Hyper-responsiveness to tactile stimuli might include expressing distress during grooming, reacting emotionally or aggressively to touch, becoming irritated by wearing shoes or socks, avoiding going barefoot, or having difficulty standing in a line close to others (Dunn, 1997). Hypo-responsiveness might include decreased awareness of pain and temperature, not seeming to notice when their face or hands are messy, avoiding wearing shoes, or displaying an unusual need for touching certain toys, surfaces or textures. Hyper-responsiveness and hypo-responsiveness to tactile stimuli have often been reported in children with ASC (Baranek, *et al.*, 1997; Cascio, McGlone, Folger, Tannan, Baranek, Pelphrey et al, 2008). Children with ASC have been reported to tolerate narrower food preferences, have more feeding problems and are more resistant to trying new foods than children who do not have ASC (Lockner, Crowe, & Skipper, 2008).

The underlying reason for repetitive stereotypical behaviours or strong aversive responses to commonly occurring sensory experiences in children with ASC has been attributed to either generating or avoiding sensory stimulation or to attempts to achieve homestasis or to modulate the sensory system (Baker *et al.*, 2008). Children with ASC who have sensory disorders can also experience psychological stress related to the sensory impairment. Ben-Sasson and colleagues found that the consequences associated with these perceptual differences may include anxiety related behaviours or disorders and may have a detrimental impact on self-concept or social empathy (Ben-Sasson *et al.*, 2009). A strong correlation between sensory defensiveness and anxiety, and between hypo-responsiveness and symptoms of depression were found in children with Asperger Syndrome (Pfeiffer, Kinnealey, Reed, & Herzberg, 2005). The evidence suggests that there is potential for sensory and perceptual dysfunction to explain many of the behavioural observations of friends, family, clinicians and experiences reported by individuals with ASC. There is strong evidence for the presence of sensory and perceptual experiences amongst the ASC population, however the question remains as to how they may be consolidated within other research findings concerning aetiology.

The heritability of ASC has been one of the most important changes in our conception of the condition since the first pioneering descriptions of the mid 20$^{th}$ century, becoming the most reliably reported risk factor for ASC (Folstein & Rutter, 1988; Bolton & Rutter, 1990; Rutter, 2005). Twin studies have shown a concordance rate in monozygotic (identical) twin pairs of about 60% compared with a rate of 5% in dizygotic (fraternal) pairs. The rate of ASC in the siblings of individuals with autism is about 6%, higher than the rate of about 0.5% in the general population, resulting in a 90% concordance rate for the broader ASC phenotype (Ronald, Happe, Bolton, Butcher, Price, Wheelwright *et al.*, 2006). These findings suggest reliable genetic influences for autism, and it has been argued that multiple genes are involved (Maestrini et al, 2000) with between 3 and 12 susceptibility genes that interact to increase ASC risk (Rutter, 2005), and locations on several chromosomes, in particular 7 as well as 2, 26 and 17 have been replicated (International Molecular Genetic Study of Autism Consortium, 1998). Although ASC is highly heritable, the identification of candidate genes has been hindered by the heterogeneity of the syndrome and insufficient numbers of participants (Bill & Geschwind, 2009).

Researchers over the past half century have focussed on searching for the causes and cures for ASC as a whole, based on the assumption that the triad of impairment that define ASC must be explained together. However, more recent scientific interest has been focussed on identifying homogeneous subtypes of ASC based on phenotype and genetic or neurobiological markers (Lord & Spence, 2006; Rapin & Tuchman, 2008; Rutter, 2005). For example, the basic assumption that the diagnostic criteria for ASC require a unitary explanation has been questioned, suggesting instead that the triad of impairment can be fractionated and studied separately (Happe, Ronald & Plomin, 2006). Reporting data from over three thousand twin pairs assessed between the ages of seven and nine, Ronald and colleagues (Ronald *et al.*, 2006) found modest to low correlations between autistic-like behavioural traits in the three core areas. Even social and communication impairments, suggested to result from a single cognitive deficit (Baron-Cohen, Tager-Flusberg, & Cohen, 2000) were only modestly related with correlations in the range of 0.2-0.4. This relationship was no stronger than that between communication difficulties and repetitive behaviour (0.3-0.4), whereas social impairments and repetitive behaviours were least strongly linked (0.1-0.3). Ronald and colleagues concluded that in middle childhood, it is possible that the degrees of social difficulty, communicative impairment and repetitive behaviour are only modestly related (Ronald *et al.*, 2006). Is has also been suggested that phenotypical separability of the triad is mirrored at the genetic level. A comparison of three thousand monozygotic and dizygotic twin pairs at ages seven and eight years suggests that each aspect of the triad is highly heritable (Happe, *et al.*, 2006). It seems improbable that the range of clinical presentation can be explained by an individual cognitive or anatomical abnormality caused by aberrant expression of a single gene (Viding & Blakemore, 2007), and by fractionating the autistic phenotype into component parts links have been established between genotypic variation and the integrity of brain areas (Gottesman & Gould, 2003). However, without 100% concordance for monozygotic twins, factors other than genetics must be involved (Rapin & Tuchman, 2008).

Brain imaging, post-mortem examination and electrophysiology have been used extensively to investigate potential neurological influences in autism. The most consistently reported anatomical abnormalities in the brains of individuals with autism involve the cerebellum and limbic system (Bauman & Kemper, 2005). Specifically related to the cerebellum, the most notable, well replicated, neuroanatomical finding is deficiencies in the number of Purkinje cells (Kemper & Bauman, 1998; Rapin & Katzman, 1998). Since Purkinje cells serve to regulate arousal by dampening stimulation to the reticular activating system of the brainstem, a decrease in Purkinje cells could result in oversensitivity to sensory input (Reeves, 2001). Cells in the amygdala and hippocampus of the limbic system are reported to be atypically small but more numerous and densely packed than expected. The hippocampus plays a role in learning and memory by habituating to stimuli and inhibiting the amygdala and reticular formation so one can focus on a task. Based largely on the constellation of symptoms that characterise ASC, various anatomical sites within the brain had been suggested as possible primary sources of pathology, including the medial temporal lobe, the thalamic nuclei, the basal ganglia, and the vestibular system. However, early investigations failed to report consistent abnormalities. Salient findings began to emerge in the late 1980s with reports of reduced cell size and increased cell packing density increased numbers of neurons per unit volume) in the amygdala, entorhinal cortex, subiculum, mamilliary bodies and septum of the limbic system (Bauman & Kemper, 1985; Bauman, 1991). Abnormalities have also been found in the cerebellum and cerebellar circuits with the loss of Purkinje cells and to a lesser extent granule cells consistently found primarily in the neocerebellar cortex. Major abnormalities in the forebrain have been found in specific regions of the limbic system related to each other by closely interconnecting circuits. Portions of these involved areas in turn are related to the limbic neocortex and to the reticular formation, receiving direct projections from the sensory association cortex. Thus the anatomical abnormalities may disrupt function of hippocampal, amygdala, limbic, reticular and sensory association formations.

An interesting area of recent research concentrates on the importance of neocortical organisation and circuitry during developmental stages and brought to light some basic cytoarchitectural characteristics which underlie the cluster of behaviours characterising ASC. Minicolumns are considered the basic architectonic and physiological elements and have been identified in all regions of the neocortex (Buxhoevedon, Fobbs, & Casanova, 2002). The minicolumnar circuit is an evolutionary and ontogenetically preserved model, organising neurons in cortical space and modified in various cortical areas according to their specific developmental and functional requirements. (Mountcastle, 1997). The interaction of diverse projection and interneuron types within the developing cell column gives rise to characteristic architectonic components and response properties within the adult cell minicolumn (Kozlosk, Hamzei-Sichani, & Yuste, 2001; Casanova *et al.*, 2003). In a minicolumn, a core array of pyramidal projection neurons ascends vertically between layers VI and VII, mostly cumulating in a linear trend delimited by peripheral neuropil space (Casanova, van Kooten, Switala, van Engeland, Heinsen, Steinbusch *et al.*, 2006). At the core and periphery of the minicolumn, combinations of GABAergic interneurons serve to modulate pyramidal cell inputs and outputs that perform region and task specific processing requirements (Casanova, Buxhoeveden, & Gomez, 2003; DeFelipe, 1997; Gupta, Wang & Markram, 2000; Just, Cherassky, Keller, & Minshew, 2004). Double-bouquet cells in the peripheral neuropil space of minicolumns provide a vertical stream of negative inhibition (Mountcastle, 1997) surrounding the minicolumnar core. Other GABAergic cells in the minicolumn, having adjacent projections extending hundreds of microns tangentially, provide lateral inhibition of surrounding minicolumns on a macro-columnar scale.

The profile of activity arising from a minicolumn represents the net influence of short-range excitatory and inhibitory output on neighbouring minicolumns, sharpening the boundary between competing macrocolumnar fields (Casanova, 2006). This may provide the basis for overlapping fields of lateral inhibition, which influence in combination the excitatory output of each minicolumn in the network. Each minicolumn’s response to thalamic input is modulated by the activity of its neighbours to a greater of lesser degree determined by GABAergic interneurons in its peripheral neuropil space, This allows for gradations in amplitude of excitatory activity across a minicolumnar field. Rubenstein & Merzenich (2003) posited that reductions in GABAergic inhibitory activity may explain some symptomatology in autism, including increased incidence of seizures and sensory hypersensitivity. In this model, loss of inhibition corresponds to reduced peripheral neuropil and narrower minicolumns, prone to form islands of coordinated excitatory activity. Their autonomous activity would hinder the binding of associated cortical areas, arguably promoting focus on particulars as opposed to general features.

Casanova and colleagues measured minicolumnar morphometry relative to pyramidal cell arrays and found reduced minicolumnar width and peripheral neuropil spacing, and increased mean cell spacing most significantly in the dorsolateral prefrontal cortex and anterior cingulated gyrus (Casanova, van Kooten, Switala, van Engeland, Steinbusch, & Schmitz, 2006; Casanova, Buxhoeveden, Switala, & Roy 2002a; 2002b). Despite the increase in intracolumnar cell spacing, the number of cells per minicolumn was comparable to that of controls, indicating that the increase in cortical cell density is due to greater overall mincolumnar density (Casanova, Van Kooten, Switala, Van Egelandm Heinsen, Steinbusch *et al.*, 2006; Williams & Casanova, 2010). A cortical bias towards smaller neurons imposes a metabolic constraint on connectivity, facilitating signal delays and inefficient disparate functional connectivity (Chklovskii, & Koulakov, 2004, Belmonte, Allen, Belckel-Mitchener, Boulanger, Carper, & Webb, 2004; Horwitz, Rumsey, Grady & Rapoport, 1988; Just *et al.*, 2004). Furthermore, short association fibres have been found to be overrepresented in ASC (Herbert, Zeigler, Makris, Filipek, Kemper, Normandin, *et al.*, 2004), and with concomitant increase in total number of minicolumns, a bias for cortical connectivity favouring local rather global information processing may result in superior abilities for tasks involving local information processing (McClelland, 2000).

The widespread corticocortical and corticosubcortical connections of the prefrontal lobes integrate and coordinate information processing within the context of parallel and widely distributed neural networks (Mesulam, 1990). Rather than being confined to one particular cognitive domain, the executive functions simplify behaviours rendering them stimulus bound, that is the range of self-determined behavioural options curtailed and appears to be more reflexive or environmentally determined. Disturbances in prefrontal cortical function provide for a brain which is less equipped to use learning as an adaptive strategy and has diminished resources (plasticity) to handle social interaction. At the macroscopic level, the brain weight of specimens sampled was increased by 100g to 200g in autistic children, but did not differ significantly in adult patients relative to controls. Other post-mortem studies have revealed similar evidence of increased brain weight, whereas clinical and MRI studies reported bigger head circumferences and brain volumes in autism (Walker, 1977; Davidovitch *et al.*, 1996; Woodhouse, Baily, Rutter, Bolton, Baird & le Couteur, 1996). More recently, several studies have demonstrated a postnatal acceleration in brain growth resulting, between

2 and 4 years of age, in increased brain volume in autistic children relative to controls (Courchesne, Karns, Davis, Ziccardi, Carper, Tigue *et al.*, 2001, Courchesne, Carper, & Akshoomoff 2003). This phase coincides with the initial presentation of symptoms. By adolescence, differences in mean brain size between the two groups diminish largely as a result of increased relative growth in the normal control group (Courchesne *et al.*, 2001; Aylward, Minshew, Field, Sparks, & Singh, 2002; Sparks, Friedman, Shaw, Aylward, Echelard, Artru *et al.*, 2002). In autistic children, increases in cerebral grey matter, cerebral white matter, and cerebellum cause an enlarged brain volume. Increases in white matter volume and brain weight in postnatal development appear proportionate, as myelin contributes the most toward increases in brain weight during the first years of life, suggesting a widely distributed underlying pathology in autism.

Research into ASC has been steered by a variety of ideologies and epistemological assumptions each contributing to the development of explanatory models or theories including Executive Dysfunction Theory (Ozonoff, Pennington & Rogers, 1991), Theory of Mind (Baron-Cohen, Leslie & Frith, 1985), and Weak Central Coherence (Frith, 1989). Baron-Cohen and colleagues' early theory of autism, which has proven fairly robust, specifies a mechanism which underlies a crucial aspect of social skills, specifically being able to conceive of mental states. That is, knowing what other people know, want, feel or believe. In other words, social and communicative disabilities could be the result of impairment in the development of a Theory of Mind, or the capacity for 'mindreading'. This is defined as the ability to attribute mental states to ones' self and others, and make sense of and predict behaviour on the basis of mental states. This is held to be important to autism simply because it is arguably the way in which the normal individual succeeds in understanding and participating in social relationships and communication.

Wimmer and Perner (1983) devised the false belief task to test when normally developing children show evidence of possessing theory of mind. The child was presented with a short story involving one character not being present when an object is moved, and therefore not knowing that the object is in a new location. The child being tested is asked where the character thinks the object is. Normal 4 year olds were able to correctly infer that the character thinks the object is where the character has left it, rather than where it actually is. When the test is given to a sample of children with autism, despite having a mental age equivalent to a four-year old or above, 80% of them failed the test by indicating that the character thinks the object is where it actually is (Baron-Cohen, Leslie & Frith, 1985). That is, they appeared to disregard the critical fact that, by virtue of being absent during the critical scene, the character's mental state would necessarily be different to the child's own mental state. By contrast, 86% of children with Down Syndrome, with generally lower ability levels than the children with autism, passed the test question. The implication was that the ability to infer mental states may be an aspect of social intelligence that is relatively independent of general intelligence (Cosmides, 1989), and that children with autism might be specifically impaired in the development of a theory of mind.

Theory of mind involves mental states other than false beliefs. Children and adults with ASC have also been shown to have deficits in their understanding of pretence, irony, non-literal language and deception (Hill & Frith, 2003; Baron-Cohen, 1992; Sodian & Frith, 1992; Happe, 1994).. The majority of children with autism also perform at chance levels on tests of the mental-physical distinction (Baron-cohen, 1989a). That is, they do not show a clear understanding of how physical objects differ from thoughts about objects. They also have an appropriate understanding of the functions of the brain, but have a poor understanding of the functions of the mind (Baron-Cohen, 1989a). That is, they recognise that the brain's physical function is to make you move and do things, but they do not spontaneously mention the mind's mental function. Most children with autism also fail to make the appearance-reality distinction, meaning that, in their description of misleading objects (*e.g.* a red candle in the shape of an apple), they do not distinguish between what the object looks like and what they know it really is (Flavell, Green, and Flavell, 1986). Children with autism also fail tests assessing if they understand the principle that "seeing leads to knowing" (Baron-Cohen & Goodhart, 1994; Leslie & Frith, 1988). For example, when presented with two dolls, one of whom touches a box, and another of whom looks inside a box, and when asked "which one knows what's inside the box?", they are at chance in their response.

Whereas normally developing children are rather good at picking out mental state words (*e.g.* like, know, and imagine) in a word list that contains both mental state words and non-mental state words, most children with autism are at chance. In contrast they have no difficulty in picking out words describing physical states. Nor do most children with autism produce the same range of mental state words in their spontaneous speech (Tager-Flusberg, 1992). They are also impaired in the production of spontaneous pretend play (Baron-Cohen, 1987; Wing, Gould, Yeates, & Brierley, 1977; Lewis & Broucher, 1988). Typical children of even 2 years old distinguishes between when someone else is acting veridically, versus when they are just pretending (Leslie, 1987). Typically developing children make rapid sense of such behaviour, presumably because they can represent the latter case as being driven by the mental state of pretending. They also spontaneously generate examples of pretence themselves, and do not show any confusion as they switch back and forth between pretence and reality. In contrast, most children with autism produce little pretence, and often appear confused about what pretence is for, and when someone is or is not pretending (Baron-Cohen, 1999). Baron-Cohen and colleagues take this evidence to suggest that there is a lack of normal understanding of mental states that leads to autism being conceptualised as involving degrees of mindblindness (Baron-Cohen, 1990, 1995). There appears to be an impairment in the development of a theory of mind in the majority of cases with autism. This finding has the potential to explain the social, communicative and imaginative abnormalities that are diagnostic of the condition, since being able to reflect on one's own mental states, and those of others would appear t be essential in all of these domains Baron-Cohen, 1999).

Joint attention refers to those behaviours produced by the child which involve monitoring or directing the target of attention of another person, so as to coordinate the child's own attention with that of somebody else. Such behaviours include the pointing gesture, gaze monitoring, and showing gestures, most of which are absent in most children with autism. These behaviours are usually well developed by the age of 14 months (Scaife & Bruner, 1975; Butterworth, 1991), so their absence in autism signifies a very early occurring deficit. It has been argued that the joint attention should be understood as a precursor to the development of mind-reading (Leekham, Baron-Cohen, Perrett & Milders, 1997; Philips, Baron-Cohen & Rutter, 1992; Phillips, Gomez, Baron Cohen, Riviere, & Laa, 1995; Baron-Cohen, Allen, & Gillberg, 1992; Baron-Cohen, Cox, Baird, Swettenham, Drew, Nightingale, & Charman, 1996).

The non-social features of autism include repetitive and obsessive behaviours and uneven patterns of intelligence resulting in strengths and weaknesses that are perhaps less well understood than the social features. One cognitive theory that has sought to address both deficits and assets in ASD is the 'weak coherence' account (Frith, 1989), which alludes to poor connectivity throughout the brain between more basic perceptual processes and top-down modulating processes. Central coherence refers to an information processing style, specifically the tendency for typically developing children and adults to process incoming information for meaning and gestalt (global) form, often at the expense of attention to or memory for details and surface structure. Individuals with ASC were hypothesised to show 'weak central coherence", a processing bias for featural and local information, and relative failure to extract gist or context in everyday life. This processing bias was evident in early work on verbal memory, showing relatively little benefit from meaning (Hermelin & O'Connor, 1967). Frith argues that the superior ability on the embedded figures test seen in autism (Shah & Frith, 1983), and on an unsegmented version of the block design subtest of the WAIS (Shah & Frith, 1993), arises because of a relative immunity to context effects in autism.

The original suggestion of a core deficit in central processing, manifest in failure to extract global form and meaning has changed from a primary problem to a more secondary outcome- with greater emphasis on possible superiority in local or detai-focused processing. The idea of a core deficit has given way to the suggestion of a processing bias or cognitive style, which can be overcome in tasks with explicit demands for global processing (Happe & Frith, 2006). One example is that individuals with ASC show raised thresholds for perceiving coherent motion (Gepner & Mestre, 2002). Superior visual search and reduced susceptibility to visual illusions have been reported (Ropar & Mitchell, 1999; 2001). As well as fairly consistent findings from relatively robust tasks that appear to be good probes of weak coherence, for example Block Design and the embedded figures test, there have been inconsistent and negative findings (*e.g.* Ropar & Mitchell, 1999; 2001; Mottron, Burack, Stauder & Robaey, 1999). In particular, Plaisted and colleagues reported that local advantage and interference from local to global stimuli in a condition where participants with ASC were required to divide attention between local and global levels, but not selective attention task in which participants were instructed to pay attention. Reduced or absent global advantage may therefore only be evident when participants with ASC are not explicitly required to attend.

A similar pattern of results have been reported across sensory modalities (Snowling & Frith, 1986; Frith & Snowling, 1983; Happe, 1997; Jolliffe & Baron Cohen, 1999; Lopez & Leekham, 2003; Lopez, Donelly, Hadwin, & Leekham, 2004). Happe and Frith go on to argue for a processing bias rather than a deficit, lending to the possibility of weak coherence being part of a broad continuum in which extremely weak central coherence of ASC is seen as one end of a normal distribution, with strong coherence at the opposite end and characterised by a tendency to process gist and global form at the expense of attention and memory for detail and surface form. With focussed, effortful attention, someone with a particular processing style is able to revert to a different processing style to fit the task (Happe & Frith, 2006). Frith's original conception (Frith, 1989) gave weak coherence a central and causal role, with problems integrating information for high level meaning underlying the deficits in social understanding. However, the fact that detail-focussed processing can be found across the autism spectrum, regardless of level of theory of mind performance (Happe, 1997; Joliife & Baron-Cohen, 1997; 1999) suggests that these two aspects of the phenotype may be distinct (Happe, 2000; 2001). It currently appears most plausible to consider ASC the result of anomalies affecting a number of core cognitive processes including global-local processing, social cognition and executive functions.

Executive function is traditionally used as an umbrella term for abilities such as planning, working memory, impulse control, inhibition and shifting attention and monitoring of action (Shallice, 1988; Baddeley, 1991; Norman & Shallice, 1980; Stuss & Knight, 2002). Executive functioning allows the person to allocate the limited attentional resources needed to process a situation, and is perhaps best understood as a general domain with processes that are fluid and very dependent on context for expression, thus differ based on the construct being measured (*i.e.* planning, response inhibition), and also the context in which it is being expressed (Bernsein & Waber, 2007). However, since the first report of its relationship to Autism Spectrum Conditions (Steel, Gorman & Flexman, 1984) the role of executive functions have attracted a great deal of debate (see Pennngton & Ozonoff, 1996). Several studies evaluating executive function in children with ASC have found deficits in the areas of planning and cognitive flexibility (Hill, 2004; Kenworthy, Black, Wallace, Ahluvalia, Wagner, & Sirian, 2005; Ozonoff, Cook, Coon, Dawson, Joseph, Klin *et al*., 2004; Sergeant, Geurts, & Oosterlaan, 2002), response selection/monitoring (Happe, Booth, Charlton, & Hughes, 2006; Nyden, Gillberg, Hjelmquist, & Heiman, 1999) and task initiation/task shifting (Hill & Bird, 2006). Systematic reviews of the literature offer mixed evidence for executive dysfunction in Autism Spectrum conditions, arising from a number of issues including the nature of the tasks and samples used, with studies predominantly focussing on group comparisons whilst ignoring the possibility of individual variation. There is also some debate surrounding the reliability and validity of tests reported to measure executive dysfunction (Hill & Bird, 2006). The basic notion is that without a "central executive" or a "supervisory attentional system", actions are controlled by the environment, such that the organism simply responds to cues which elicit behaviour. Without Supervisory attentional system, action schemas or motor programs contend between themselves for execution, as evidenced by individuals with frontal lobe damage.

A whole range of tests purport to measure some aspects of executive dysfunction. These include classical tests such as the Modified Card Sorting Task (MCST; Nelson, 1976), the Verbal Fluency Test (Perret, 1974), and more contemporary tests such as the Six Elements Test (SET; Wilson, Alderman, Burgess, Emslie, & Evans, 1996). The MCST is a measure of mental flexibility, where participants must sort cards on one of three possible dimensions (colour, number or shape) according to an undisclosed rule. The experimenter tells the participant whether they have placed each card correctly, but does not give the rule explicitly. After correctly sorting six cards, the rule is changed and the participant must adapt to a new dimension for sorting the cards. Such classical tests of executive dysfunction have been criticised for the difficulty to generalise results to real-life situations. In contrast, the SET is a multi-component task testing planning, organisation and behaviour monitoring. Participants must carry out six separate tasks within ten minutes, but are not permitted to carry out two of the same tasks consecutively. Whilst participants are not expected to complete each task, they must carry out at least part of all six. Contemporary assessments such as the SET are claimed to mirror real-world settings more appropriately (i.e. ecologically valid). There is good evidence that patients with frontal lobe damage fail on these tasks (see Shallice, 1988), and so do people with autism (Runsey & Hamberger, 1988; Prior and Hoffman, 1990; Ozonoff, Pennigton, and Rogers, 1992; Hughes & Russel, 1993; Hughes Russell, and Robins, 1994). Whilst there seems little doubt that in autism there is an executive dysfunction, and that this is likely to be a sign of frontal pathology, however executive dysfunction occurs in a large number of clinical disorders, for example Schizophrenia (Frith, 1992; Elliot, McKenna, Robbins, & Sahakian, 1995); Obsessive Compulsive Disorder (Christensen, Kim, Drysken, & Hoover, 1992; Zelinski, Taylor, & Juzwin, 1991), Tourette's Syndrome (Bornstein, 1990; Baron-Cohen & Robertson, 1995); Attention Deficit Hyperactivity Disorder (Loge, Staton, & Beatty, 1990), and therefore is not specific to, and cannot itself explain ASC (Baron-Cohen, 1999).

Cognitive explanations of the core features of autism have provided a vital interface between brain and behaviour. They attempt to provide explanations in terms of faults in mechanisms of the mind that normally underlie specific mental functions and facilitate learning in specific domains. Despite considerable supporting evidence, in isolation these theories are incapable of accounting for all of the developmental, social, cognitive and affective variance defining autism psychopathology, with fundamental physiological processes and genetics the popular alternative focus. Far from being mutually exclusive, theory of mind deficit, executive dysfunction, weak central coherence, genetic and neurophysiological evidence can be reconciled when approached from the perspective of sensory and perceptual differences. With minicolumnar pathology suggesting a bias toward local over global processing, there are obvious connections with the weak central coherence theory of autism. Furthermore, a bias for processing local information at the expense of contextual information, allows for compromised perceptual organisation as the child develops. Binding of important information regarding the sensory experience of a stimulus and associated meaning is less efficient and potentially very different in autism which would likewise compromise their responses to sensory input. By dividing sensory processing into the seven modalities of vision, auditory, olfactory, gustatory, tactile, proprioceptive and vestibular, it is possible to predict that variation in clinical phenotype can be explained by a subtle variation in the type of sensory processing profile and perceptual experiences of the individual. By studying the patterns of sensory and perceptual processing abilities of individuals with ASC, it may be possible to uncover further sub-groups within the spectrum and increase the sensitivity of future diagnostic criteria and guide clinical intervention.

The Sensory Profile Checklist Revisited (SPCR; Bogdashina, 2003) is a 232 item questionnaire which aims to assess the sensory and perceptual experiences of individuals with an ASC based on their behavioural responses. The items and structure of the measure are based in clinical observation and first-hand accounts of sensory and perceptual differences expressed by individuals with high-functioning autism and Asperger syndrome. The reliability and validity of the measure have not been explored and the aim of the current research is to explore the factor structure of the SPCR and to analyse the correlation between its scores, a measure of autism severity and a standardised measure of sensory function. It is predicted that the factor structure of the SPCR will reflect the 7 sensory modalities presented by Bogdashina (2003), with items 1-50 dealing with visual sensory and perceptual processing, items 51-92 dealing with auditory sensory and perceptual processing, items 93-125 dealing with tactile sensory and perceptual processing, items 126-150 dealing with olfactory sensory and perceptual processing, items 151-175 dealing with gustatory sensory and perceptual processing, items 176-207 dealing with proprioceptive sensory and perceptual processing, and items 207-232 dealing with vestibular sensory and perceptual processing. Good internal consistency is also predicted with Cronbach's alphas expected to range from moderate to high. Furthermore, it is expected that Individuals with a clinical diagnosis of ASC will score significantly higher on this measure overall, and for each of the extracted factors than healthy controls.

The Autism Quotient (AQ; Baron-Cohen *et al.*, 2001), is a 50 item questionnaire designed to measure the extent which an individual has the personality traits associated with ASC. The original analysis resulted in five theoretically derived sub-scales consisting of ten items each: social skill, communication, imagination, attention to detail, and attention switching. Higher scores on the measure are consistent with greater ASC symptomatology. The measure has consistently reported good test-retest reliability and moderate internal consistency (Cronbach's alphas ranging from .63 to .78). Summed scores > 32 are considered clinically significant. For the purposes of the present research, the factor structure of the AQ will be analysed, with the prediction that theoretical predictions of previous research will be upheld. Primarily, the AQ will be used as a measure of ASC symptom severity, as has been reported in previous literature (Hill & Bird, 2007), with the prediction that there will be a meaningful correlation between total scores of the AQ and total scores of the SPCR. It is further predicted that each of the sub-scales of the AQ will be predictive of scores on the extracted factors of the SPCR.

Finally, the ability of the SPCR to reliably report sensory and perceptual processing abilities will be assessed by analysing the correlation between total scores on the SPCR and scores on a standardised measure of sensory processing ability. The measure used in the present study is the ASP, designed as a trait measure of sensory processing abilities and has been shown to differentiate sensory processing abilities of ASC, ADHD, and healthy controls. It is predicted that scores on the ASP will be meaningfully correlated with scores on the SPCR. It is further predicted that sub-scales of the ASP will correlate with the extracted factors of the SPCR, and that individuals with a clinical diagnosis will score significantly higher on the ASP compare to healthy controls

# Method

## Participants

A total of 200 people were invited to participate in the current research. One hundred people working within ASC support services, supporting individuals with a range of ASCs in the Lothian area of Scotland were invited to participate in the study by post. 100 people were invited to participate through an internet link posted on social networking sites and through the University of Edinburgh electronic mailing system. Ethical approval was obtained from the University of Edinburgh, College of Humanities and Social Science, Psychology Research Ethics Committee. Exclusion criteria included past or present medical or psychiatric disorder other than ASC that could affect cognitive function. After removal of incomplete submissions there was an overall response rate of 39% (40% of clinical sample and 38% non-clinical). Demographic information including age, gender and years in education was collected. 70.5% of responses were based on male subjects and 29.5% female, with subject age ranging from 18 – 56 years (*N*=78).

## Measures

Years in education was measured using a 1 – 5 point scale, with respondents asked to check 1 for "0-6 years / up to secondary school", 2 for "7-11 years / up to college higher education", 3 for "12-13 years/ up to university further education", 4 for 14-17 years / up to postgraduate education", and 5 for "18 years and above". Ethnic origin was measured using a 1-4 point scale, and respondents were asked to check 1 for "Black", 2 for "white", 3 for "Asian", 4 for "Other".

The Sensory Profile Checklist Revisted (SPCR; Bogdashina, 2003) is a 232 item screening tool designed to compile a sensory profile of an individuals with autistic spectrum conditions. Its descriptors have been based on personal first hand-accounts of individuals with ASCs and clinical observations of autistic children. It includes 20 categories through all 7 sensory systems including visual (*e.g.* "Avoids direct eye contact"), auditory (*e.g.* "will hear a few words instead of a whole sentence"), tactile (*e.g.* "Resistant to touch and will move away from people"), olfactory (*e.g.* "Seeks strong odours"), gustatory (*e.g.* "Craves plain foods"), proprioceptive (*e.g.* "Clumsy, moves stiffly), and vestibular (*e.g.* "Rocks unconsciously during other activities") to cover possible patterns of sensory experiences. The measure is completed by the parents or the carer of the individual with autism, who are asked to respond to a statement (*e.g.* Resists any change) by ticking a box representing whether the statement is "never observed", "rarely observed", "sometimes observed", "often observed", or "frequently observed".

The Autism Quotient (AQ; Baron-Cohen et al, 2001) is a self-administered questionnaire designed to measure the extent to which adults possess the traits associated the ASC. Although the scale is not a diagnostic measure, its discriminative validity as a screening tool has been clinically tested (Woodbury-Smith, Robinson, Wheelright, & Baron-Cohen, 2005). In addition, traits as assessed by the AQ show high heritability (Hoekstra, Bartels, Verweij, & Boomsa, 2007) and are stable cross-culturally (Wakabayash, Baron-Cohen, & Wheelwright, 2006). The test consists of 50 items, made up of 10 questions assessing five sub-scales: social skill ("I would rather go to a library than a party"), communication ("I frequently find that I do not know how to keep a conversation going"), imagination ("when I'm reading a story, I find it difficult to work out the characters intentions"), attention to detail ("I usually notice car number plates or similar strings of information"), and attention shifting ("I frequently get so absorbed in one thing that I lose sight of other things"). Respondents are asked to express whether they "definitely agree", "slightly agree", "slightly disagree" or "definitely disagree". To date, all studies examining the criterion validity of these factors have uniformly found support for at least the 'social skill' and 'attention to detail' components, and some for the 'communication' component (Austin, 2005; Hoekstra, Bartels, Cath, & Boomsma, 2008; Hurst, Nelson-Gray, Mitchell, & Kwapil, 2007; Stewart & Austin, 2008; Stewart & Ota, 2008).

The Adult/Adolescent Sensory Profile (ASP; Brown & Dunn, 2002) was designed as a trait measure of sensory processing, a 60 item self-report measure to evaluate behavioural responses to everyday sensory experiences. Based on patterns of sensory processing described by in Dunn's (1997) Model of Sensory Processing, the 60 items are divided into equal quadrants identified as Low Registration, Sensation Seeking, Sensory Sensitivity and Sensation Avoiding, with each quadrant covering the sensory processing categories of Taste/Smell, Movement, Visual, Touch, Activity Level, and Auditory. An individual completes the questionnaire by indicating the frequency of a response ("Almost Never", "Seldom", "Occasionally", "Frequently", "Almost Always") to various sensory experiences.

**Procedure**

Participants were asked to complete the questionnaires based on their observations of people whom they have known for over 6months. Informed consent was obtained from both participants completing the ratings, and subjects who had their behaviour observed and rated.

**Clinical sample***:* Reporting participants were issued with research packs containing the information and consent forms for reporters and the ASC subject, demographic questionnaire, SPCR, AQ, and ASP, and asked to return the completed forms within two weeks using prepaid postage envelopes. To assess inter-rater reliability of the measure, 50 participants were asked to form pairs and fill in research packs independently reporting on the same individual with an ASC that both reporters knew well. Pairs of questionnaires relating to the same individual were given matching identification numbers for analysis.

**Control sample***:* Completing an online version of the research pack, participants were asked to follow the on-screen instructions, to confirm consent from the individual upon whom they were basing their responses, and to confirm their own consent by checking a mandatory field prior to proceeding with the questionnaire. Participants were then presented with the demographic questionnaire, SPCR, AQ and ASP, which were completed by checking the relevant boxes. Data from the online version of the questionnaire were stored automatically on a secure server once submitted.

## Results

Data for the SPCR were screened for univariate outliers, and cases with more than 10 missing values were removed from the analysis. Communalities were all well above .3, confirming that each item shared some common variance with other items and was therefore suitable for factor analysis. Principle components analysis was used because the primary purpose was to reduce the large number of observed variables to a smaller number of components explaining the maximal amount of variance of the items. A scree plot of the eigen values was generated and identified 5 possible solutions. Four, five, six, seven, and eight factor solutions were examined, using promax rotations of the factor loading matrix. The four factor solution, which explained 30.8% of the variance, was preferred as each factor was represented by a similar number of items and the factor loadings appeared to come closest to simple structure.

Thirteen items were eliminated because they did not contribute to a simple factor structure and failed to meet a minimum criteria of having a primary factor loading of .2 or above (items 23, 28, 48, 55, 96, 96, 140, 145, 44, 151, 202, 206 and 225). A principle components factor analysis of the remaining 219 items using promax rotation was conducted, with the 4 factors explaining 30.82% of the variance. All items had primary loadings over .2, factor loadings for this final solution are presented in *Table 1*. The factor labels hypothesised by Bogdashina (2003) failed to explain the extracted factors. Internal consistency for each of the extracted factors was examined using Cronbach's alpha. Analysis of the proportions of questions from Bogdashina's original factors, revealed that factor 1 from the present solution consisted of 71 items (*a*=.95), with a high proportion of those items dealing with spatial awareness and proprioception. Factor 2 consisted of 46 items (*a*=.92), with a high proportion of items dealing with sensory sensitivity particularly for olfactory and gustatory stimuli. Factor 3 consisted of 56 items (*a*=.92), with a high proportion of items dealing with auditory and visual sensory modulation. Factor 4 consisted of 42 items (*a*=.90) with a high proportion of those items dealing with fluctuating sensory experiences and vestibular sensory modulation. Overall, these analyses indicated that four distinct factors were underlying responses to the SPCR and that these factors were highly internally consistent.

*Table 1.* Factor loadings for the Four factor solution of the SPCR.

| | Question | Cor. |
|---|---|---|
| Factor 1 | | |
| 1 | Resistant to changes in routine | .589 |
| 3 | Does not recognise familiar environments if approached from a different direction | .296 |
| 5 | Not fooled by optical illusions | -.393 |
| 12 | looks intensely at objects and people | .248 |
| 13 | Moves fingers and objects in front of eyes | .594 |
| 15 | Runs hands around the edges of objects | .349 |
| 16 | Maintains proximity to the perimeter of rooms and spaces | .376 |
| 17 | Gets easily tired under florescent lights | .253 |
| 22 | Gets lost easily | .585 |
| 24 | Has difficulty catching balls | .601 |
| 26 | Makes compulsive hand head or body movements that fluctuate from near to far | .437 |
| 27 | Hits or rubs eyes when distressed | .368 |
| 29 | Ritualistic behaviour | .356 |
| 32 | Sudden outbursts of self-abuse and tantrums in response to visual stimuli | .519 |
| 34 | Avoids direct eye contact | .365 |
| 42 | Excellent visual memory | -.488 |
| 45 | Remembers routes and places | -.471 |
| 47 | Poor at mathematics | .699 |
| 49 | Has difficulty with adverbs and prepositions | .728 |
| 50 | Idiosyncratic patterns of language development | .732 |
| 52 | Does not seem to understand instructions if more than one person is speaking at once | .571 |
| 66 | Makes loud rhythmic noises | .374 |
| 68 | Tries to break sound producing objects | .254 |
| 70 | Response to certain sounds may vary from pleasure to distress at different times and different situations | .407 |
| 71 | Will hear a few words instead of a whole sentence | .477 |
| 72 | Pronunciation problems | .599 |
| 75 | Sometimes does not appear to hear anything | .540 |
| 76 | Response to sounds, questions, instructions are delayed | .493 |
| 77 | Echolalia | .439 |
| 87 | Excellent auditory memory. | -.386 |

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|---|---|---|
| 89 | Uses idiosyncratic routinised responses | .450 |
| 91 | Cannot keep track of conversations | .711 |
| 93 | Unable to distinguish between light and rough touch | .534 |
| 94 | Resistant to touch and will move away from people | .424 |
| 95 | Difficulty tolerating new clothes, wearing shoes | .281 |
| 119 | Seems to feel the physical pain of others | -.349 |
| 127 | Toileting problems | .689 |
| 130 | Smears and plays with faeces | .667 |
| 132 | Bedwetting | .581 |
| 137 | Hits nose when distressed | .255 |
| 143 | Sometimes does not react to any smell | .245 |
| 152 | Poor eater | .515 |
| 154 | Gags, vomits easily | .626 |
| 157 | Mouths and licks objects | .515 |
| 166 | Sudden outbursts of self-abuse and tantrums in response to certain flavours | .316 |
| 174 | Displays a good memory for tastes | -.417 |
| 176 | Clumsy, moves stiffly | .642 |
| 177 | Odd body posturing | .732 |
| 178 | Difficulty manipulating small objects | .767 |
| 179 | Turns their whole body to look at something rather than just turning their head | .469 |
| 181 | Has a weak grasp, sometimes drop things | .377 |
| 182 | A lack of awareness of the body in space | .616 |
| 183 | Unaware of their own bodily sensations | .737 |
| 184 | Bumps into objects and people | .388 |
| 185 | Appears floppy, often leaning against people and walls | .458 |
| 186 | Stumbles frequently and has a tendency to fall | .551 |
| 187 | Rocks back and forth | .490 |
| 189 | Often engaged in complex body movements of body positions especially when frustrated or bored | .565 |
| 193 | Difficulty with hopping, jumping, skipping, riding a bicycle etc | .755 |
| 195 | Very poor at sports | .783 |
| 196 | Tires very easily during physical activity | .609 |
| 198 | Has difficulty imitating and copying movements | .870 |
| 199 | Difficulty controlling the movement of their limbs to accommodate a particular task | .786 |

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| 201 | Watches their hands whilst doing something | .334 |
| 210 | Has difficulty walking or crawling on uneven or unstable surfaces | .435 |
| 215 | Fears falling and heights | -.244 |
| 218 | Resistant to new motor activities | .554 |
| 219 | Walks on tiptoes | .465 |
| 221 | Seems oblivious to risk of heights etc | |
| 227 | Rocks unconsciously during other activities | .523 |
| 229 | Appears to be in constant motion | .421 |
| | | |
| Factor 2 | | |
| 21 | Selects for attention minor aspects of objects in the environment instead of the whole thing | .277 |
| 36 | Surprises with knowing ‘unknown’ information | .395 |
| 63 | Likes the kitchen and bathroom | .311 |
| 81 | Looks for the sources of sounds | .422 |
| 92 | Excellent musical ability , composing musical pieces and songs | .417 |
| 98 | Dislikes food of a certain texture | .407 |
| 100 | Insists on wearing the same clothes | .254 |
| 103 | Hugs tightly | .501 |
| 104 | Enjoys rough and tumble activities | .593 |
| 107 | Cannot tolerate certain textures | .465 |
| 109 | Responses to certain tactile stimulation may be different depending on the time or situation etc. | .628 |
| 110 | Complains about the parts of clothes | .420 |
| 124 | Displays a good tactile memory | .484 |
| 126 | Unable to distinguish between strong and weak odours | .449 |
| 128 | Avoids smells | .401 |
| 129 | Smells self, people and objects | .499 |
| 131 | Seeks strong odours | .485 |
| 133 | Cannot tolerate certain smells | .538 |
| 134 | Is fascinated with certain smells | .610 |
| 136 | Complains about the smell of some pieces of food whilst ignoring the rest | .491 |
| 138 | Hits nose when distressed | .394 |
| 139 | Has difficulty interpreting smells | .371 |
| 141 | Does not seem to sense smell when looking at or listening to something else | .392 |

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|---|---|---|
| 142 | Avoids direct smells | .381 |
| 144 | Will smell food before eating | .590 |
| 149 | Displays a good memory for smells | .586 |
| 150 | Reactions are triggered by smells | .626 |
| 153 | Uses the tip of the tongue to taste before eating | .491 |
| 155 | Gags, vomits easily | .628 |
| 158 | Mixes food before eating | .511 |
| 160 | Cannot tolerate certain foods | .492 |
| 161 | Is fascinated with certain tastes | .692 |
| 162 | Response to the same taste may be different depending on the time and situation etc | .634 |
| 163 | Is confused with or complains about foods they used to enjoy | .587 |
| 164 | Has difficulty interpreting tastes | .335 |
| 165 | Response to taste is delayed | .263 |
| 167 | Does not seem to taste anything if looking at or listening to something else | .502 |
| 169 | Sometimes does not react to any taste | .456 |
| 171 | Complains about non-existent tastes in the mouth | .248 |
| 173 | Talks or complains about tasting sensations in the mouth when looking at or listening to something else | .470 |
| 175 | Reactions are triggered by certain foods | .392 |
| 204 | Involuntary postures of the body in response to a visual or auditory stimulus, a touch, a taste or smell etc. | .544 |
| 205 | Displays a good proprioceptive memory | .394 |
| 213 | Enjoys swings, merry-go-rounds etc | .636 |
| 214 | Enjoys spinning and running in circles | .372 |
| 217 | May respond differently at different times and situations to the same movement activities | .508 |
| 230 | Involuntary movements of the body in response to visual or auditory stimuli, a taste, touch or smell. | .412 |
| Factor 3 | | |
| 2 | Notices every tiny change in the environment | .331 |
| 4 | Difficulty recognising people in unfamiliar clothes | .306 |
| 6 | Constantly looks at minute particles and picks up the smallest pieces of fluff | .444 |
| 7 | Dislikes dark and bright lights | .385 |

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| 8 | Frightened by flashes of light, lightening etc. | .507 |
| 9 | Looks down most of the time | .411 |
| 10 | Covers, closes or squints at light | .410 |
| 11 | Attracted to light | .297 |
| 14 | Fascinated by reflections and bright coloured shining objects | .587 |
| 18 | Gets frustrated with certain colours | -.225 |
| 19 | Is fascinated with coloured or shining objects | .488 |
| 30 | Delayed response to visual stimuli | .360 |
| 31 | Any experiences are perceived as new and unfamiliar, regardless of the number of times the individual has experienced the same thing | .322 |
| 33 | Does not seem to see if listening to something | .383 |
| 35 | Appears to be a mindless follower | .232 |
| 38 | Seems absorbed with lights colours and patterns | .600 |
| 40 | Covers, rubs, blinks their eyes in response to a sound, touch, smell, taste or a movement | .347 |
| 43 | Reactions are triggered by lights colours and patterns | .231 |
| 46 | Memorises enormous amounts of information at a glance | -.268 |
| 51 | Gets easily frustrated when trying to do something in a noisy and crowded room | .398 |
| 53 | Covers ears at certain sounds | .609 |
| 54 | Is a very light sleeper | .207 |
| 57 | Dislikes having haircut | .370 |
| 58 | Avoids sounds and noises | .236 |
| 59 | Makes repetitive noises to block out other sounds | .541 |
| 60 | Bangs objects, doors, furniture etc | .649 |
| 61 | likes vibration | .357 |
| 62 | Likes the kitchen and bathroom | .419 |
| 64 | Is attracted by sounds and noises | .374 |
| 65 | Tears paper, crumples it in the hand | .463 |
| 67 | Gets frustrated with particular sounds | .476 |
| 73 | Unable to distinguish between certain sounds | .417 |
| 74 | Hits ears when distressed | .537 |
| 78 | Sudden outbursts of self-abuse, tantrums in relation to sounds | .547 |
| 80 | Reacts to instruction better if presented whilst looking away from them | .353 |
| 82 | Seems to absorbed or merged with sounds | .435 |
| 85 | Covers or hits ears in response to lights or colours, a touch, texture, scent, flavour | .540 |

| | | |
|---|---|---|
| | or movement | |
| 86 | Complains about (is frustrated with) a sound in response to colours, textures, touch, scent, flavours or movement | .446 |
| 99 | Moves away from people | .318 |
| 101 | Insists on wearing the same clothes | .327 |
| 105 | Prone to self-injurious behaviour | .451 |
| 106 | Low reaction to pain and temperature | .214 |
| 108 | Fascinated with certain textures | .426 |
| 111 | Hits and bites self when distressed | .578 |
| 113 | Sudden outbursts in response to tactile stimulation | .726 |
| 114 | Does not feel touch if looking at or listening to something else | .452 |
| 115 | Fails to define either the location or texture of touch | .219 |
| 116 | Can tolerate only instrumental not social touch | .204 |
| 118 | Seems absorbed with certain textures | .517 |
| 125 | Reactions triggered by tactile stimuli | .427 |
| 156 | Eats anything, even inedible (pica) | .440 |
| 159 | Regurgitates | .266 |
| 168 | Careful to keep different foods separate and eat them one by one | .223 |
| 170 | Seems absorbed with certain foods | .267 |
| 180 | Low muscle tone | .370 |
| 216 | Spins, jumps, rocks when frustrated or bored | .325 |
| | | |
| Factor 4 | | |
| 20 | May respond differently at different times and situations to the same visual stimuli | .351 |
| 25 | Appears startled when being approached | .401 |
| 39 | Seems to know what other people, who are not in the immediate surroundings are doing | .262 |
| 41 | Complains about or is frustrated with the wrong colour of letters | .317 |
| 69 | Fascination with certain sounds | .439 |
| 79 | Does not seem to hear if looking at something | .347 |
| 83 | Seems to be able to read the thoughts and feelings of others | .385 |
| 84 | Complains about non-existent conversations, sounds | .265 |
| 88 | Reactions are triggered by sounds and words | .421 |
| 90 | Uses commercials, popular phrases to respond | .549 |
| 112 | Feels/acts numb | .326 |

| | | |
|---|---|---|
| 117 | Sometimes does not react to tactile stimulation | .382 |
| 120 | Complains about touch, hot or cold etc in the absence of any stimuli | .580 |
| 121 | Complains about sensing colour or sound when being touched | .444 |
| 122 | Complains about feeling touch when being looked at | .697 |
| 123 | Complains about aches, pains, temperature in colourful, noisy or crowded environments | .545 |
| 135 | Responses to the same smell may differ depending on the time or situation etc. | .444 |
| 146 | Complains or talks about non-existent smells | .258 |
| 147 | Covers, rubs or hits nose in response to visual or auditory stimuli, touch, taste or movement | .445 |
| 148 | Complains about, gets frustration with a smell in response to visual or auditory stimuli, a touch a taste or movement | .441 |
| 172 | Makes swallowing motions in response to visual, auditory stimulation | .204 |
| 188 | Cannot tolerate certain movements of the body and head positions | .243 |
| 190 | Muscle tone may vary from tense to very relaxed depending on the time or situation | .511 |
| 191 | Pencil lines, letters and words are uneven | .395 |
| 192 | Complains about their limbs or particular parts of the body | .473 |
| 194 | Does not seem to be aware of what their body is doing | .322 |
| 197 | Does not seem to know the position of their body in space, or what their body is doing , when looking at something, listening or talking to someone | .432 |
| 200 | Watches their feet whilst walking | .286 |
| 203 | Complains about non-existent physical experiences *e.g.* floating | .479 |
| 207 | Mimics actions when instructions are being given | .513 |
| 208 | Resists change to head position/movement | .432 |
| 209 | Fearful reactions to ordinary movement activities | .432 |
| 211 | Dislikes having head upside down | .268 |
| 212 | Becomes anxious or distressed when feet leave the ground | .422 |
| 220 | Becomes disoriented after changes to head position | .473 |
| 222 | Holds head upright even when leaning or bending over | .708 |
| 223 | Gets nauseated or vomits from excessive movement | .299 |
| 224 | Does not seem to mind any movement activities when looking at or listening to something else | .329 |
| 226 | Becomes disoriented after physical activity | .428 |
| 228 | Inspects surfaces before walking on them | .318 |

| | | |
|---|---|---|
| 231 | Experiences movement whilst being still | .508 |
| 232 | Reactions are triggered by motor activities | .661 |

The principle components analysis resulted in 4 theoretically defined constructs. For the purposes of the current research these will be relabelled as “spatial and proprioceptive processing” (Factor 1), “olfactory and gustatory processing” (factor 2), “auditory and visual processing” (factor 3), and “inconsistent or fluctuating sensory processing style” (factor 4). The data does not support the prediction that the SPCR can be reduced to 7 underlying factors dealing with the 7 sensory modalities, however, the extracted factors suggest that the underlying constructs are sensory and perceptual in nature.

The suitability of the AQ data for reduction using factor analysis was tested with Bartlett’s test of sphericity, which was significant ($\chi^2$ (1225) = 3171.19, p<0.5), and the Kaiser-Meyer-Olkin measure of sampling adequacy which was .81, above the recommended minimum value of .6. Finally, the communalities were all above .3, further confirming that each item shared some common variance with other items. Principle axis factoring was used to analyse the factor structure of ASC traits underlying the AQ. A scree plot of the eigen values was generated and identified 3 possible solutions (*figure 1*). Three, four and five factor solutions were examined, using promax rotations of the factor loading matrix. The 3 factor solution, which explained 48.31 % of the variance, was chosen as each factor was similarly represented with a clear levelling of eigen values on the scree plot after 3 factors.

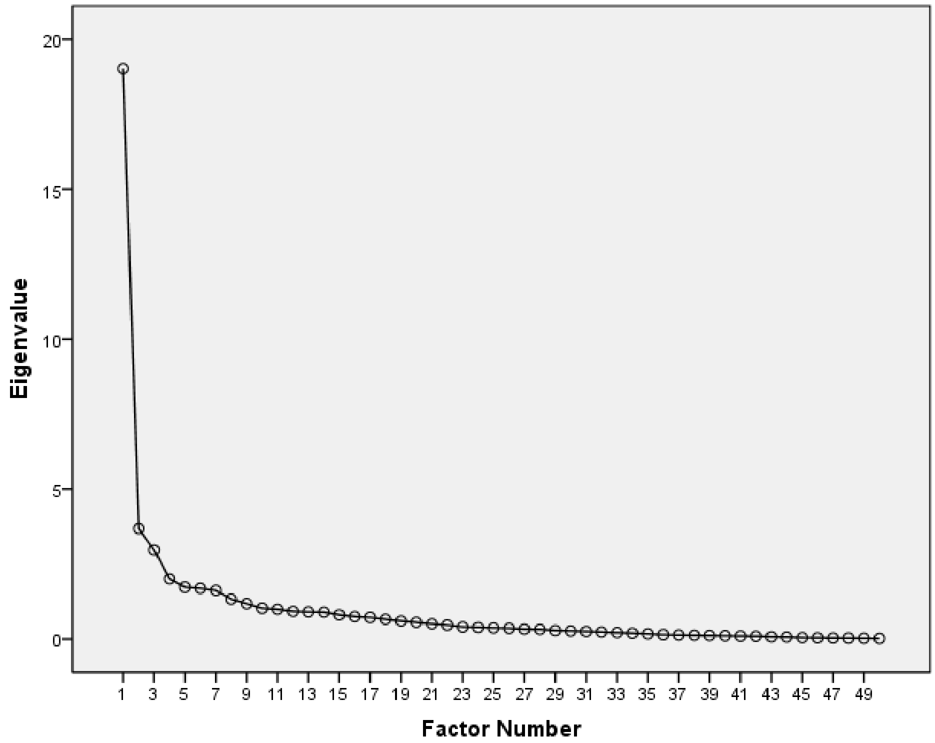


*Figure 1.* Scree plot showing the initial eigen values for the items of the AQ.

Factor loadings for this final solution are presented in *Table 2*. Analysis of the items for each of the extracted factors revealed that factor 1consisted of 23 items (*a*=.92), a high proportion of which were dealing with the social skills and imagination sub-sets proposed in the original literature. Factor 2 consisted of 19 items (*a*=.67), mainly dealing with the communication and attention switching sub-sets proposed in the original literature. Factor 3 consisted of 8 items (*a*=.56), mainly dealing with the attention to detail sub-set proposed in the original literature. For the purposes of the current research, the extracted factors have been relabelled as “Social skill and imagination” (factor 1), “communication and multi-tasking” (factor 2), and “attention to detail” (factor3). The data does not support the findings of previous literature that the AQ can be reduced to 5 underlying factors.

*Table 2.* Factor loadings for the three factor solution of the AQ

| | Question | Cor. |
|---|---|---|
| Factor 1 | | |
| 1 | Prefer to do things with others rather than on their own | .857 |
| 2 | Prefer to do the same things over and over again | -.556 |
| 3 | Finds it easy to imagine images in their minds | .853 |
| 11 | Finds social situations easy | .804 |
| 14 | Finds making up stories easy | .885 |
| 15 | Are drawn more strongly to people than to things | .702 |
| 18 | When they talk, it isn't always easy for others to get a word in edgeways | .303 |
| 24 | Would rather go to the theatre than a museum | .704 |
| 27 | Find it easy to "read between the lines" when someone is talking to them | .695 |
| 30 | Don't usually notice small changes in a situation or a person's appearance | .491 |
| 31 | Knows how to tell if someone listening to them is getting bored | .736 |
| 32 | Finds it easy to do more than one thing at once | .417 |
| 36 | Finds it easy to work out what someone is thinking or feeling just by looking at their face | .841 |
| 37 | If there is an interruption, they can switch back to what they were doing very quickly | .805 |
| 38 | They are good at social chit chat | .435 |
| 40 | When they were young, they used to enjoy playing games involving pretending with other people | .452 |
| 47 | Enjoys meeting new people | .613 |
| 48 | Good diplomat | .439 |
| | | |
| Factor 2 | | |
| 4 | Frequently gets so strongly absorbed in one thing losing sight of other things | .516 |
| 5 | Often notice small sounds when others do not | .184 |
| 7 | Other people frequently tell them that what they've said is impolite, even if they think it is polite | .709 |
| 16 | Tend to have very strong interests and get upset if they can't pursue them | .602 |
| 17 | When they talk it isn't always easy for others to get a word in edgeways | -.441 |
| 20 | When reading a story, they find it difficult to work out the characters intentions | .397 |

| | | |
|---|---|---|
| 21 | Don't particularly enjoy reading fiction | .419 |
| 22 | Find it hard to make new friends | .395 |
| 25 | Does not upset them if their daily routine is disturbed | -.474 |
| 26 | Frequently find that they don't know how to keep a conversation going | .618 |
| 29 | Not very good at remembering phone numbers | .408 |
| 33 | When they talk on the phone, they're not sure when it is their turn to speak | .783 |
| 35 | Often the last to understand the point of a joke | .760 |
| 39 | People often tell them that they keep going on and on about the same thing | .613 |
| 42 | They find it difficult to imagine what it would be like to be someone else | .691 |
| 43 | They like to plan activities they participate in carefully | .683 |
| 44 | Enjoy social situations | -.413 |
| 46 | New situations make them anxious | .526 |
| | | |
| Factor 3 | | |
| 6 | Usually notices car number plates or similar strings of information | .543 |
| 9 | Fascinated by dates | .681 |
| 12 | Tend to notice details that others do not | .262 |
| 13 | Would rather go to a library than a party | .411 |
| 19 | fascinated by numbers | .602 |
| 23 | Notice patterns in things all the time | .414 |
| 41 | They like to collect information about categories of things | .640 |
| 49 | Not very good at remembering people's dates of birth | -.294 |

In order to test the hypothesis that AQ scores are predictive of scores on the SPCR, multiple regression analysis was performed. Controlling for age, sex and years in education, AQ scores were found to have a significant effect on SPCR scores with a single score increase in AQ scores predictive of 3.49 point increase in SPCR scores ($b$=3.49, $t(76)=4.795$, $p<.05$) and accounted for a significant amount of the overall variance in SPCR scores ($R^2= .232$, $F(1,76)=22.994$, $p<.05$). The hypothesis that ASP scores are predictive of scores on the SPCR was also tested using multiple regression analysis. Controlling for age, sex and years in education, ASP scores were found to have a significant effect on SPCR scores, with a single score increase in ASP scores predictive of 2.78 point increase in SPCR scores ($b$=2.78, $t(36)=8.885$, $p<0.05$) and accounted for a significant amount of the overall variance in SPCR scores ($R^2=.61$, $F(1,37)=78.944$, $p=.05$).

Pearson's correlation coefficients were calculated to examine interrelationships between extracted factors of the SPCR, AQ and the previously defined factors of the ASP. Each of the extracted SPCR factors were modelled individually using multiple regression analysis. Factor 1 of the SPCR (spatial processing and proprioception) was found to be predicted by factors 1 (low registration) ($b$=2.172, $t(36)$=4.980, $p$=.05) and 3 (sensory seeking; $b$=1.561, $t(36)$=3.521, $p$=.05) of the ASP and factor 2 (communication and multi-tasking), $b$=2.318, $t(36)$=2.486, $p$=.05) of the AQ, accounting for a significant amount of the overall variance in SPCR factor 1 scores ($R^2$=.659, $F(3,35)$=539.331, $p$=.05).

Factor 2 (Olfactory and gustatory processing) of the SPCR was found to be predicted by factors 1 (low registration; $b$=.735, $t(36)$=3.231, $p$=.05) and 2 (sensory seeking; $b$=.779, $t(36)$=2.902, $p$=.05) of the ASP, and accounted for a significant amount of the overall variance in factor 2 scores of the SPCR ($R^2$=.294, $F(2,36)$=157.291, $p$=.05). Factor 3 (auditory and visual processing) of the SPCR was found to be predicted by factor 3 (sensory seeking) of the ASP ($b$=1.836, $t(36)$=4.278, $p$=.05) and factors 2 (communication and multi-tasking; $b$= -2.223, $t(36)$= -2.475, $p$=.05) and 3 (attention to detail; $b$= -5.980, $t(36)$= -3.149, $p$=.05) of the AQ, and predicted a significant amount of the overall variance in factor 3 scores of the SPCR ($R^2$=.432, $F(3,35)$=8.873, $p$=.05).

Factor 4 (inconsistent or fluctuating sensory processing style) of the SPCR was found to be predicted by factor 4 (sensation avoiding) of the ASP ($b$=.739, $t(36)$=2.280, $p$=.05) and factors 1 (social skill and imagination; $b$= -1.779, $t(36)$= -2.926, $p$=.05) and 3 (attention to detail; $b$=2.732, $t(36)$=2.074, $p$=.05) of the AQ, accounting for a significant amount of the overall variation in factor 4 scores of the SPCR ($R^2$=.316, $F(3,35)$=5.397, $p$=.05). The total score of the SPCR was found to be predicted by Factors 1 ($b$=4.083, $t(36)$=6.166, $p$=.05), 2 ($b$=2.568, $t(36)$=2.993, $p$=.05) and 3 ($b$=4.083, $t(36)$=5.362, $p$=.05) of the ASP, accounting for a significant amount of the overall variance in SPCR total scores. ($R^2$=.716, $F(3,35)$=29.426, $p$=.05). Finally, the hypothesis that individuals with an ASC diagnosis score significantly higher on the SPCR than individuals without a diagnosis was tested using regression analysis, controlling for age, sex and education. Individuals with an ASC were found to score significantly higher than healthy controls ($b$=78.496, $t(77)$=4.577, $p$=.05) and accounted for a significant amount of the variance in overall SPCR scores ($R^2$=.465, $F(1,76)$=20.953, $p$=.05).

## Discussion

The present study contributes to the understanding of the pattern of sensory and perceptual processing in adults with ASC. Several useful trends have been observed in a small dataset which present useful avenues for future research. The prediction that the 232 items of the SPCR can be explained by 7 factors reflecting the 7 sensory modalities (visual, auditory, tactile, olfactory, gustatory, proprioceptive and vestibular) was not supported by the data. Principle components analysis revealed 4 factors dealing with spatial and proprioceptive processing, olfactory and gustatory processing, auditory and visual processing, and inconsistent or fluctuating sensory processing. Items in the spatial and proprioceptive processing factor included “Maintains proximity to the perimeter of rooms and spaces”, “Has difficulty catching balls”, and “Makes compulsive hand head or body movements that fluctuate from near to far”. The majority of items corresponded to what were considered to deal with visual and proprioceptive sensory and perceptual processing differences by Bogdashina (2003). It may not be surprising to find some visual processing and proprioceptive processing items having equal loading with the same factor, as proprioceptive processing abilities would rely heavily on visual feedback during early development, and it might be assumed that distorted visual perception would lead to difficulty understanding the positioning of the body in relation to other things. It could be predicted that with a larger sample size, the visual and proprioceptive items might form separable constructs as a wider range of sensory and perceptual behaviours are reported.

The same is true of olfactory and gustatory sensory processing, which included items such as “seeks strong odours”, “cannot tolerate certain smells”, and “response to taste is delayed”. With a larger sample size items relating to olfaction may well be a separable from items dealing with gustatory processing, forming distinct factors. However, it is unsurprising to find items relating to olfaction and gestation loading equally onto the same factor. The sensation of taste relies on the sense of smell, and without efficient olfactory sensory processing, perception of smells and therefore taste would be compromised. Auditory and visual processing, including items such as “constantly looks at minute particles and picks up the smallest pieces of fluff”, “covers, closes or squints at light”, and “gets easily frustrated when trying to do something in a noisy and crowded room”, may also be separable with a higher number of responses. The loading of visual and auditory related items on the same factor may be explained with their relationship to social understanding and being the primary means of interacting with one’s environment. Hearing and vision are central to an individual’s development throughout the lifespan, without efficient visual and auditory sensory and perceptual processing, an individual's ability to interpret and negotiate the environment would be profoundly altered.

Inconsistent or fluctuating sensory processing style included items relating to sensory processing abilities that alter depending on the time and situation, such as "may respond differently at different times and situations to the same visual stimuli", "sometimes does not react to tactile stimulation", and "responses to the same smell may differ depending on the time or situation etc." These items were representative of all sensory modalities, and it could be predicted that even with a greater number of respondents, fluctuating sensory processing would be separable from pure sensory sensitivities in each of the modalities. Further research into the nature and pattern of inconsistent sensory processing is required. Each of the extracted factors demonstrated high internal consistency, suggesting the measure has reasonable construct validity. With an increased response rate and a more representative sample, it could be argued that the extracted factors could be further sub divided to reflect the original 7 factors suggested by Bogdashina (2003). The prediction that individuals with a clinical diagnosis would score significantly higher on the SPCR compared with healthy controls was supported by the data, however with such a low response rate and variability amongst both clinical and general populations, further research would be required before any conclusion could be reasonably drawn.

The prediction that the 50 items of the AQ can be explained by 5 factors reflecting social skill, communication, imagination, attention to detail and attention switching was not supported by the data, with principle axis factoring revealing 3 factors dealing with social skills and imagination, communication and attention switching, and attention to detail. Social skills and imagination, including items such as "finds it easy to imagine images in their minds" and "finds social situations easy" could be separable with a greater number of respondents. However, it could be argued that imagination is required in order to have effective social skills, for example, Theory of mind deficit theory of ASC suggests that social skills require the ability to infer the mental states of others which requires the ability to imagine how another person might be feeling or what they might be thinking etc. This is a skill that has been reported to develop at approximately 3 years, and shapes our interaction with others. Therefore it is perhaps unsurprising to find items relating to both social skills and imagination loading equally onto a common factor. Communication and attention switching are related to each other in as much as effective communication requires an ability to switch attention from one person to another, and one subject to another as the conversation develops. These factors also demonstrated high internal consistency. The prediction that individuals with a clinical diagnosis of ASC would score more highly on the AQ when compared to healthy controls was supported by the data, however validity is compromised by low response rates. Subjects of the control sample consisted mainly of university educated students from the UK studying arts and humanities degrees. In order to assess the full range of ASC traits in the general population as measured by the AQ, future research may seek to recruit equal numbers of participants from engineering, physics and mathematics courses as well as arts and humanities and other fields

Spatial and proprioceptive processing of the SPCR was found to correlate with low registration and sensory seeking behaviour of the ASP. Items such as “looks intensely at objects and people”, “moves fingers and objects in front of eyes”, “runs hands around the edges of objects”, “makes compulsive hand head or body movements that fluctuate from near to far” and “bumps into objects and people” are considered to be sensory seeking behaviours which, according to Bogdashina (2003), may indicate a need for more stimulation in order understand the information before them, similarly described by Dunn (1997) as low registration. Spatial and proprioceptive processing was also found to correlate with communication and multi-tasking of the AQ. It seems that the ability to navigate the environment successfully would require the ability to integrate visual and proprioceptive information simultaneously. As such it could be considered that the spatial and proprioceptive processing difficulty is related to a multi-tasking difficulty more than the communication aspect of the factor. Olfaction and gustatory processing were also associated with low registration and sensory seeking factors of the ASP. Items including “smells self, people and objects”, “seeks strong odours”, “mixes food before eating”, and “is fascinated with certain tastes” are considered to be behaviours resulting from the need for greater stimulation in those particular senses in order to interpret smells and tastes, consistent with low registration and the need to seek sensory stimulation described by Dunn (1997). Auditory and visual sensory and perceptual processing was found to be positively correlated with sensory seeking items of the ASP, but negatively correlated with communication and multitasking, and attention to detail of the AQ. items of the SPCR such as “attracted to lights”, “fascinated by reflections and bright coloured shining objects”, “bangs objects, doors, furniture etc”, and “is attracted by sounds and noises” are also considered to be sensory seeking behaviours by Bogdashina (2003), and indicative of the need for increased sensory stimulation in order to make sense of visual and auditory stimulation.

Inconsistent or fluctuating processing style of the SPCR was found to be correlated with social skill and attention switching and attention to detail of the AQ, and sensation avoiding of the ASP. Items of the SPCR such as “complains about touch, hot or cold etc in the absence of any stimuli”, “complains about, gets frustrated with a smell in response to visual or auditory stimuli, a touch a taste or movement", "fearful reactions to ordinary movement activities", and "cannot tolerate certain movements of the body and head positions", are considered to be indicative of hypersensitivity to sensory stimulation in a particular sensory modality, and such sensory avoiding behaviour reduces the sensory demand on the individual. The ability to modulate and integrate sensory information from all senses simultaneously is essential in order to make sense of the immediate environment. fluctuating and inconsistent sensory ad perceptual processing will make it extremely difficult an demanding to make sense of the world, particularly the multi-sensory demands of social interaction. The overwhelming nature of fluctuating and inconsistent sensory and perceptual information processing may result in those individuals concentrating on fine details in order to "block out" excessive stimulation. Overtime, this may become a bias towards local processing as described by the weak-central coherence theory, consistent with attention to detail of the AQ.

The results suggest that there is a pattern of sensory and perceptual processing style specific to ASC clinical diagnosis when compare to healthy controls, however, without a larger sample size from both clinical and control groups including representatives from other clinical populations, the severity, universality and uniqueness of sensory and perception processing styles to ASC cannot be adequately explored. Future research may also include other psychiatric conditions as comparison groups to assess the sensory and perceptual processing styles of ASC compared to those of *e.g.* Down's Syndrome, ADHD, Schizophrenia etc.

Any conclusions relating to the results of the current research must be drawn with caution, and with regard to some important limitations. Firstly, the number of cases in relation to the number of items has serious implications for the use of data reduction methods including principle components analysis and principle axis factoring. With 232 items for the SPCR and 50 for the AQ, at least 300 participants would be appropriate for statistical analysis The low response rates could be improved for future research by advertising to a wider audience and offering incentives for participation.  The diversity of participants was also limited. The vast majority of subjects in both clinical and control samples were of white British origin, and it may be that there are cultural variations in the presentation of sensory and perceptual processing abilities that could be better explored with a more diverse sample. Educational level was poorly matched between clinical and control groups, with the majority of clinical subjects falling between 0-6 years of education and the majority of healthy controls having 12 years or above. In order to explore the effect of education on sensory and perceptual abilities, both samples would need to be much larger and have equal representation from both clinical and control population incorporating all levels of educational achievement. It may be that individuals with ASCs and a high level of educational ability experience less sensory and perceptual disturbances than those with low educational ability and learning difficulties. On the other hand, it may be that higher IQ and educational attainment are associated with a particular pattern of sensory and perceptual processing and behaviour. Further research is required, but the previous literature would indicate that the most susceptible to sensory and perceptual processing disturbances would be individuals with learning difficulties and low educational attainment. Socio-economic status was not assessed in the current research and would be a valuable addition to any future research. Previous research has shown that elevated sensory over-responsiveness is particularly prevalent in homes receiving state assistance, single parent families and low versus middle to high socioeconomic status (Ben-Sasson, 2009).

Test-retest reliability of the measures was not assessed during the current research due to time constraints. However, future research may seek to administer the measures at time 1, and then again three months later. It is unlikely that in such a short space of time, the sensory and perceptual processing ability of the subjects would have altered significantly and so any observed change in scores on the measures would reflect reliability over time. Anonymity of the clinical and control groups prevented the formal assessment of diagnosis. Whilst the AQ has been used as a measure of ASC severity and as a measure of ASC traits in the general population, it cannot be used as a diagnostic tool and in future the possibility of clinical verification should be considered for both clinical and control subjects. Such a measure would also control for the prevalence of false positives in the general population through missed diagnosis.

The participants recruited to perform the observations on subjects varied in their relationship with the subject. Many of the respondents within the control sample were friends or family members, whereas the respondents reporting observations of clinical subjects were paid support workers. There is potential for different responses from these parties, for example family members may provide more accurate information as they have known the subject for much longer and have observed them in a range of situations, whereas those paid to support the subject may be more familiar with completing questionnaires and be motivated to observe the behaviour more closely in order to guide professional practice. The cross sectional design of the study is limited to observations of behaviour as they are now or perhaps in some instances how they have been in the past. This approach fails to allow for variation in sensory and perceptual experiences across the lifespan for which a longitudinal design would be required.

The results suggest that sensory and perceptual processing styles of individuals with ASC are significantly different to those of healthy controls. The items of the SPCR have been found to examine 7 underlying theoretical constructs dealing with spatial and propriocetive processing, Olfaction and gustatory processing, auditory and visual sensory processing, and inconsistent and fluctuating sensory processing styles. These constructs differ from those originally suggested by Bogdashina (2003), however, it could be argued that patterns consistent with Bogdashina's original hypothesis exist and with tighter controls and a larger sample size, the extracted factors would be separated further. The items of the AQ have been found to examine 3 underlying theoretical constructs dealing with social skill and imagination, communication and attention switching, and attention to detail. As with the SPCR it is argued that tighter controls and increased sample sizes would increase the likelihood of further separation within the extracted factors to reflect the original position of Baron-Cohen and colleagues (2001). The high correlation between items of the SPCR and the AQ suggest that the SPCR is useful tool for evaluating the sensory and perceptual experiences of individuals with ASC. Whilst it cannot be claimed to aid diagnosis, the structure of the measure is such that it would be a useful tool for parents, carers and clinical professionals to use as a guide for intervention targeted at relieving the need to engage in sensory seeking or sensory avoiding behaviours.

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